ECOLOGY OF THE MURRAY ISLAND CORAL REEF

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A quantitative ecological study was made of the Madreporian corals of the fringing reef of Maër Island, the largest of the Murray Island Group, which lies in Torres Straits, Australia, in 9°55′ S. Lat.; 144°2′ Long. E. from Greenwich.

Maër Island is volcanic and has broken through an old limestone-bearing platform which is now submerged to a depth of 15–30 fathoms, and upon which the modern coral reefs of Torres Straits have grown.

The volcanic center of the Island is surrounded by a modern fringing reef which has grown seaward over its outer edges from the shores, and is now 1800–2200 feet wide on the windward (S. E.) side of the Island, and only 175–780 feet wide on the leeward (N. W.) side. It is wide in regions exposed to the full force of the breakers, and where it is not interfered with by silt from the three principal streams of the Island; while on the other hand in regions protected from breakers or inundated by sand or silt the fringing reef is narrow. Hurricanes are unknown and thus the corals grow on uninterrupted by periods of wholesale destruction such as affect the reefs of the West Indies, and most parts of the Pacific region.

A line running S. 39° E., and 1869 feet long, was surveyed across the S. E. reef flat of Maër Island. The shore end of this line was 1496 feet in a N. E. direction from the mouth of Haddon brook. Squares 50 feet on the side (2500 feet in area) were then surveyed and staked out at intervals of about 200 feet along this line; and all living coral heads growing within these staked areas were counted.

This reef flat is peculiar in that the water is dammed by the lithothamnion ridge which extends in a narrow barrier along the seaward, breaker-washed edge of the flat. Thus at low tide the water over the reef flat becomes a marine basin about two miles long, 1680 feet wide and only about 18 inches deep; but the water being impounded by the lithothamnion ridge, the reef flat is never laid bare even by the lowest spring tides. About 3,600,000 living coral heads are found upon this submerged area. For the first 370 feet out from shore there are no corals. The following table gives the number of living coral heads found on each 50-foot square (2500 square feet) at intervals of about 200 feet apart across the S. E. reef flat or Maër Island.

Distance[1]	Living[2]	Species[3]
400	3	2
525	110	11
625	126	9
825	413	13
1025	529	15
1225	962	9
1425	1838	18
1650	1512	27
1750	201	15

[1] Distance in feet of the center of the square from shore.
[2] Number of living coral heads growing within each square (2500 square feet).
[3] Number of different species of corals on each square.

About 40 different species of corals are found growing within these squares. Of the 22 genera of corals found on these squares, four constitute 91% of the living coral heads. Thus: Porites 38%, Seriatopora 25%, Acropora 18%, and Pocillopora 10%.

Seriatopora is the most successful coral of the calm waters of the middle zone of the reef flat 1100 feet from shore where it covers 40% of the area of the bottom, and constitutes 70% of the entire number of living coral heads. In this region where Seriatopora is dominant all other species of corals are reduced in number. Yet Seriatopora cannot live within 500 feet of the shore, owing to the high temperature of the water in this region, nor can it survive in places more than 1650 feet from shore due to the destructive action of the breakers upon its fragile stems.

The coral heads are most densely clustered in a region about 200 feet inward from the usual inner 'wash' of the breakers, but an even greater variety of *species* of corals are found to the seaward of this place where the water is strongly agitated by the surges. Thus in the place where coral growth is most dense there are only 18 species, but 200 feet to seaward of this zone there are 27 species, although owing to the rough water the coral stocks are much broken and are either large massive heads capable of resisting the waves or small ones protected within crevices.

Of the 22 genera from the squares over this reef flat 13, or more than half, are confined to the seaward parts of the flat and do not commonly appear within 1200 feet of the shore. In fact only two species, Bernard's 'Porites No. 12' and a form allied to 'Siderastrea' sphaeroidalis Ortmann are practically confined to the shore flats within 1100 feet of the beach.

Temperature is the dominant factor, and is even more important than silt in determining the habitat of corals. The most sensitive

genera such as Acropora, Seriatopora, and Pocillopora are killed at from 36.2°–37°C., while Siderastrea and some species of Porites can withstand heat up to 38° or even 38.5°C. Generally speaking those forms which are sensitive to high temperature are correspondingly affected by being smothered under mud, or subjected to the influence of CO_2. This suggests that high temperature produces death by asphyxiation as postulated by Winterstein. There are however some exceptions, for certain corals such as Favia fragum and Mæandra æreolata die at a relatively low temperature but are quite resistant to asphyxiation. It appears from experiments conducted at Tortugas, Florida, that some corals can adjust themselves to a wide range of metabolic activity and can thus survive in a reduced oxygen supply by corresponding lowering their metabolic processes. Others, however, cannot effect this adjustment and must live at a fairly uniform rate of metabolism.

The more sensitive corals such as Acropora, Seriatopora, Euphyllia, or Pocillopora, which are all off-shore, pure water forms, are killed by being buried eleven hours under the mud, whereas the shore flat species of Porites, Siderastrea, and Mæandra can survive being buried from 24 to 73 hours.

The corals of this Australian reef which are never subjected to cold can nevertheless withstand low temperature quite as readily as can the the corals of the 'cold devastated' reefs of Florida; and conversely the Florida corals can withstand high temperatures quite as well as do those of Australia. In other words corals are, physiologically speaking, of similar constitution whether in the Atlantic or the Pacific; and natural selection has apparently not operated to improve their cold-withstanding or heat-resisting powers. The reef building forms must live in water which is warmer than 15°, and cooler than 38°C.

It was found that the shallow waters of the Maër Island reef flat receive most of their heat by direct radiation from the sun and lose it by radiation into outer space at night. Thus at 3 p.m. the water is from 1.2° to 6.7° higher than the air, while at 6 a.m. it is from 0.3° to 3°C. lower than the air temperature.

The range in water temperature was thus greater than that of the air; for during September and October the extreme range in air temperature was only 3.4°C. whereas the water of the reef flat 200 feet from shore ranged through 12.5°, and at 1860 feet from shore, in the breakers, the range was only 3.5°C.

Thus the waters of the shore flats within 400 feet of the beach must become too hot for coral life during the calms of the 'north west season' between November and April.

There is clear evidence of the submarine solution of a thickness of about two feet of limestone in the middle region of the Maër Island reef flat between 400–1600 feet from shore; but this may be chiefly due to the carbon dioxide washed outward from the densely forested shores of the Island during the rainy season, and not to the sea water as such.

Indeed the experiments and observations of Dole, and of Vaughan would lead to the conclusion that the sea water of coral reef lagoons lacks free CO_2 and is therefore probably incapable of dissolving limestone.

All species of reef corals survive without apparent injury an immersion for 4 to 5 hours in sea water diluted with an equal volume of rain water, and many species can withstand 11 hours of this treatment, and thus it appears that even torrential rains cannot be an important factor in the destruction of the reef flat corals of Maër Island through dilution of the water, for the tidal range is about seven feet and the incoming sea water would soon offset any dilution due to rains.

The injurious effects of rains upon coral reefs is due solely to the silt which they cause to be washed outward over the flats.

The research of which the above is an abstract, will be published by the Carnegie Institution of Washington.

CHANGES IN SHADE, COLOR AND PATTERN IN FISHES AND THEIR BEARING ON CERTAIN PROBLEMS OF BEHAVIOR AND ADAPTATION

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It is well known that the surface of many organisms is in appearance much like their environment. That is, the organisms simulate their surroundings and consequently are more or less inconspicuous. In some of these organisms the characteristics which produce such simulation are fairly permanent and the creatures correspond in appearance with, what may be termed, the general average of their environment. In others these characteristics may change rather rapidly, in such a way that the animals appear almost continuously like their surroundings, no matter how much they may change. These phenomena have always excited a lively interest in naturalists and a great amount of work has been done on them. They have been particularly prominent in discussions bearing on evolution and consequently most of the investigations concerned questions of function and origin and development, both individual and racial.